

**CLAIMS**

We claim:

- 5           1.       A method of conducting an operation including a battery pack, said method comprising the acts of:
  - monitoring a first battery pack condition at a first monitoring rate;
  - determining when a second battery pack condition reaches a threshold;
  - after the second battery pack condition reaches the threshold, monitoring
  - 10   the first battery pack condition at a second monitoring rate, the second monitoring rate being different than the first monitoring rate.
2.       The method as set forth in Claim 1 wherein the first monitoring act is performed when the second battery pack condition is at least one of equal to and greater
- 15   than the threshold.
3.       The method as set forth in Claim 1 wherein the second monitoring act is performed when the second battery pack condition is at least one of equal to and less than
- 20   the threshold.
4.       The method as set forth in Claim 1 wherein the first battery pack condition is a battery pack voltage.
5.       The method as set forth in Claim 1 wherein the second battery pack
- 25   condition is a battery pack voltage.
6.       The method as set forth in Claim 1 wherein the first battery pack condition and the second battery pack condition are the same battery pack condition.
- 30           7.       The method as set forth in Claim 6 wherein the first battery pack condition and the second battery pack condition are the battery pack voltage.
8.       The method as set forth in Claim 1 wherein the first monitoring rate is slower than the second monitoring rate.

9. The method as set forth in Claim 1 wherein the second monitoring rate is faster than the first monitoring rate.

5 10. The method as set forth in Claim 1 and further comprising the act of transferring power between the battery pack and an electrical device.

11. The method as set forth in Claim 10 wherein the transferring act includes the act of supplying power from the battery pack to an electrical device to operate the  
10 electrical device.

12. The method as set forth in Claim 11 and further comprising the acts of:  
determining when the second battery condition reaches a second threshold;  
and  
15 interrupting the supply of power from the battery pack to the electrical device to interrupt operation of the electrical device.

13. The method as set forth in Claim 1 wherein the battery pack includes a cell, and wherein the first battery pack condition is a cell voltage.  
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14. The method as set forth in Claim 1 wherein the battery pack includes a cell, and wherein the second battery pack condition is a cell voltage.

15. The method as set forth in Claim 1 and further comprising the act of  
25 connecting a controller to the battery pack, the controller performing the monitoring acts and the determining act.

16. The method as set forth in Claim 1 wherein the battery pack is a power tool battery pack, and wherein the method further comprises the act of connecting the battery  
30 pack to a power tool.

17. The method as set forth in Claim 1 wherein at least one of the first monitoring rate and the second monitoring rate is a fixed monitoring rate.

18. The method as set forth in Claim 1 wherein the first monitoring rate is about 1 measurements/second.

19. The method as set forth in Claim 18 wherein the second monitoring rate is  
5 about 100 measurements/second.

20. The method as set forth in Claim 1 wherein at least one of the first monitoring rate and the second monitoring rate is a variable monitoring rate.

10 21. The method as set forth in Claim 20 and further comprising the act of determining the variable monitoring rate.

22. The method as set forth in Claim 21 wherein the act of determining the variable monitoring rate includes the act of determining the variable monitoring rate based  
15 on at least one of the first battery pack condition and the second battery pack condition.

23. A battery pack comprising:  
a housing;  
a cell having a voltage, power being transferable between the cell and the electrical device;

5 a controller operable to control a function of the battery pack, the controller being operable with a voltage at least one of equal to and greater than an operating voltage threshold, the cell being operable to selectively supply voltage to the controller; and

a circuit operable to enable the controller to operate when the voltage supplied by the cell is below the operating voltage threshold.

10 24. The battery pack as set forth in Claim 23 wherein the circuit is operable to supply voltage to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold.

15 25. The battery pack as set forth in Claim 24 wherein the circuit includes a boost circuit operable to boost the voltage supplied by the cell to at least one of equal to and greater than an operating voltage threshold.

20 26. The battery pack as set forth in Claim 24 wherein the circuit includes a power source operable to supply voltage to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold, the power source not being operable to supply power to the electrical device.

25 27. The battery pack as set forth in Claim 26 wherein the power source includes a power component operable to supply voltage to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold.

30 28. The battery pack as set forth in Claim 27 wherein the power component includes a capacitor operable to supply voltage to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold.

29. The battery pack as set forth in Claim 27 wherein the power component includes a battery cell operable to supply voltage to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold.

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30. The battery pack as set forth in Claim 23 wherein the circuit includes a switch operable to selectively interrupt the transfer of power between the cell and the electrical device, the controller being operable to control the switch such that the voltage supplied by the cell to the controller is at least one of equal to and greater than an operating voltage threshold.

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31. The battery pack as set forth in Claim 30 wherein the switch includes a FET, the controller being operable to control the FET such that the voltage supplied by the cell to the controller is at least one of equal to and greater than an operating voltage threshold.

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32. The battery pack as set forth in Claim 23 wherein the cell is operable to supply power to the electrical device to operate the electrical device.

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33. The battery pack as set forth in Claim 32 wherein said battery pack is a power tool battery pack, wherein the electrical device is a power tool, and wherein the cell is operable to supply power to the power tool to operate the power tool.

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34. The battery pack as set forth in Claim 32 wherein, when the cell is at a low temperature, the supply of power to the electrical device causes the voltage supplied by the cell to the controller to be below the operating voltage threshold.

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35. The battery pack as set forth in Claim 34 wherein, when the cell is at a higher temperature, the supply of power to the electrical device does not cause the voltage supplied by the cell to the controller to be below the operating voltage threshold.

36. The battery pack as set forth in Claim 32 wherein, when an ambient temperature is a low temperature, the supply of power to the electrical device causes the voltage supplied by the cell to the controller to be below the operating voltage threshold.

37. The battery pack as set forth in Claim 36 wherein, when the ambient temperature is at a higher temperature, the supply of power to the electrical device does not cause the voltage supplied by the cell to the controller to be below the operating voltage threshold.

38. The battery pack as set forth in Claim 32 wherein a load on the electrical device causes the voltage supplied by the cell to the controller to be below the operating voltage threshold.

39. The battery pack as set forth in Claim 32 wherein the operating voltage threshold is about 5 volts.

40. The battery pack as set forth in Claim 32 wherein the operating voltage threshold is about 3 volts.

41. The battery pack as set forth in Claim 33 wherein the function includes interrupting the transfer of power between the cell and the electrical device.

42. The battery pack as set forth in Claim 41 wherein the cell is operable to supply power to the electrical device to operate the electrical device, and wherein the function includes interrupting the supply of power from the cell to the electrical device.

43. The battery pack as set forth in Claim 41 wherein the electrical device is a power tool, and wherein the function includes interrupting the supply of power from the cell to the power tool.

44. A method for operating a battery pack, the battery pack having a battery pack condition, the battery pack condition having a range, said method comprising the acts of:

conducting an operation including the battery pack;  
5 measuring a first measurement of the battery pack condition;  
measuring a second measurement of the battery pack condition, at least one of the first measurement and the second measurement being outside of the range;  
averaging the first measurement and the second measurement to provide an average measurement; and  
10 if the average measurement is within the range, continuing the operation including the battery pack.

45. The method as set forth in Claim 44 and further comprising the act of providing a controller, and wherein the measuring acts and the averaging act are  
15 performed by the controller.

46. The method as set forth in Claim 45 wherein the providing act includes the act of providing the battery pack including the controller.

20 47. The method as set forth in Claim 44 wherein the battery pack condition is a voltage.

48. The method as set forth in Claim 44 wherein the battery pack condition is a temperature.  
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49. The method as set forth in Claim 44 and further comprising the act of measuring a third measurement of the battery pack condition, and wherein the averaging act includes the act of averaging the first measurement, the second measurement and the third measurement to provide the average measurement.  
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50. The method as set forth in Claim 44 and further comprising the act of discontinuing the operation including the battery pack if the average measurement is outside of the range.

51. The method as set forth in Claim 50 wherein the range includes a range threshold, and wherein the discontinuing act includes the act of discontinuing the operation if the average measurement is at least one of equal to and greater than the range threshold.

5 52. The method as set forth in Claim 50 wherein the range includes a range threshold, and wherein the discontinuing act includes the act of discontinuing the operation if the average measurement is at least one of equal to and less than the range threshold.

10 53. The method as set forth in Claim 44 wherein the conducting act and the continuing act include the act of supplying power from the battery pack to an electrical device to operate the electrical device.

54. The method as set forth in Claim 53 wherein the supplying act includes supplying power from the battery pack to a power tool to operate the power tool.

15 55. The method as set forth in Claim 54 wherein the conducting act includes the act of supplying an in rush current to the power tool, the act of supplying the in rush current causing at least one of the first measurement and the second measurement to be outside of the range.

20 56. The method as set forth in Claim 54 wherein the conducting act includes the act of supplying a speed control signal to the power tool, the act of supplying the speed control signal causing at least one of the first measurement and the second measurement to be outside of the range.

25 57. The method as set forth in Claim 54 wherein the conducting act includes the act of stalling the power tool, the act of stalling the power tool causing at least one of the first measurement and the second measurement to be outside of the range.

30 58. The method as set forth in Claim 44 wherein the conducting act and the continuing act include the act of supplying power to battery pack to charge the battery pack.



59. A method of conducting an operation including a battery pack, said method comprising the acts of:

monitoring a battery pack condition; and

controlling a function of the battery pack, the controlling act including the

5 acts of

when the battery pack condition is in a first range, controlling the function with a first response time for the function, and

when the battery pack condition is in a second range, controlling the function with a second response time for the function, the second response time  
10 being different than the first response time.

60. The method as set forth in Claim 59 and further comprising the act of providing a controller, and wherein the monitoring act and the controlling act are performed by the controller.

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61. The method as set forth in Claim 60 wherein the providing act includes the act of providing the battery pack including the controller.

62. The method as set forth in Claim 59 wherein the battery pack condition is a  
20 voltage.

63. The method as set forth in Claim 59 wherein the battery pack condition is a temperature.

25 64. The method as set forth in Claim 59 wherein the monitoring act includes the acts of

measuring a first measurement of the battery pack condition,

measuring a second measurement of the battery pack condition, and

averaging the first measurement and the second measurement to provide an

30 average measurement.

65. The method as set forth in Claim 64 wherein the controlling act includes the acts of

when the average measurement is in the first range, controlling the function with the first response time for the function, and

5 when the average measurement is in the second range, controlling the function with the second response time for the function.

66. The method as set forth in Claim 59 and further comprising the act of conducting an operation including the battery pack.

10 67. The method as set forth in Claim 66 wherein the function is the act of discontinuing the operation including the battery pack.

68. The method as set forth in Claim 67 wherein the first range includes a range  
15 threshold.

69. The method as set forth in Claim 68 wherein the discontinuing act includes the act of discontinuing the operation if the average measurement is at least one of equal to and greater than the range threshold.

20 70. The method as set forth in Claim 68 wherein the discontinuing act includes the act of discontinuing the operation if the average measurement is at least one of equal to and less than the range threshold.

25 71. The method as set forth in Claim 68 wherein the range threshold is between the first range and the second range.

72. The method as set forth in Claim 66 wherein the conducting act includes the act of supplying power from the battery pack to an electrical device to operate the  
30 electrical device.

73. The method as set forth in Claim 72 wherein the supplying act includes supplying power from the battery pack to a power tool to operate the power tool.

74. The method as set forth in Claim 72 wherein the conducting act includes the act of supplying an in rush current to the power tool, the act of supplying the in rush current causing the battery pack condition to be in one of the first range and the second range.

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75. The method as set forth in Claim 72 wherein the conducting act includes the act of supplying a speed control signal to the power tool, the act of supplying the speed control signal causing the battery pack condition to be in one of the first range and the second range.

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76. The method as set forth in Claim 72 wherein the conducting act includes the act of stalling the power tool, the act of stalling the power tool causing the battery pack condition to be in one of the first range and the second range.

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77. The method as set forth in Claim 66 wherein the conducting act includes the act of supplying power to battery pack to charge the battery pack.

78. The method as set forth in Claim 59 wherein the first response time is slower than the second response time.

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79. The method as set forth in Claim 59 wherein the first response time is faster than the second response time.

80. The method as set forth in Claim 59 wherein at least one of the first response time and the second response time is fixed.

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81. The method as set forth in Claim 59 wherein at least one of the first response time and the second response time is variable.

82. The method as set forth in Claim 81 and further comprising the act of determining the one of the first response time and the second response time.

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83. The method as set forth in Claim 59 wherein the function includes the act of interrupting the transfer of power between the cell and the electrical device.

84. The method as set forth in Claim 83 wherein the cell is operable to supply power to the electrical device to operate the electrical device, and wherein the function includes the act of interrupting the supply of power from the cell to the electrical device.

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85. The method as set forth in Claim 83 wherein the electrical device is a power tool, and wherein the function includes the act of interrupting the supply of power from the cell to the power tool.

86. A battery pack comprising:  
a housing;  
a cell supported by the housing, power being transferable between the cell  
and an electrical device;  
5 a circuit supported by the housing and operable to control a function of the  
battery pack; and  
a heat sink in heat transfer relationship with the circuit and operable to  
dissipate heat from the circuit.

10 87. The battery pack as set forth in Claim 86 wherein the circuit includes a  
controller, and wherein the heat sink is in heat transfer relationship with the controller and  
operable to dissipate heat from the controller.

15 88. The battery pack as set forth in Claim 86 wherein the circuit includes a  
switch operable to interrupt the transfer of power between the cell and the electrical  
device, and wherein the heat sink is in heat transfer relationship with the switch and  
operable to dissipate heat from the switch.

20 89. The battery pack as set forth in Claim 88 wherein the switch includes a  
FET, and wherein the heat sink is in heat transfer relationship with the FET and operable  
to dissipate heat from the FET.

25 90. The battery pack as set forth in Claim 89 wherein the circuit includes a  
controller, and wherein the heat sink is in heat transfer relationship with the controller and  
operable to dissipate heat from the controller.

91. The battery pack as set forth in Claim 86 wherein the function includes  
interrupting the transfer of power between the cell and the electrical device.

30 92. The battery pack as set forth in Claim 91 wherein the cell is operable to  
supply power to the electrical device to operate the electrical device, and wherein the  
function includes interrupting the supply of power from the cell to the electrical device.

93. The battery pack as set forth in Claim 91 wherein the electrical device is a power tool, and wherein the function includes interrupting the supply of power from the cell to the power tool.

94. A method of conducting an operation including a battery, the battery including a cell having a voltage, power being transferable between the cell and the electrical device, a controller operable to control a function of the battery pack, the controller being operable with a voltage at least one of equal to and greater than an operating voltage threshold, the cell being operable to selectively supply voltage to the controller, said method comprising the act of enabling the controller to operate when the voltage supplied by the cell is below the operating voltage threshold.

95. The method as set forth in Claim 94 wherein the battery includes a circuit operable to supply voltage to the controller, and wherein the enabling act includes the act of, with the circuit, supplying a voltage to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold.

96. The method as set forth in Claim 95 wherein the circuit includes a boost circuit operable to boost the voltage supplied by the cell, and wherein the supplying act includes boosting the voltage supplied to the controller by the cell to at least one of equal to and greater than an operating voltage threshold.

97. The method as set forth in Claim 95 wherein the circuit includes a power source operable to supply voltage to the controller, the power source not being operable to supply power to the electrical device, and wherein the supplying act includes the act of supplying voltage from the power source to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold.

98. The method as set forth in Claim 97 wherein the power source includes a power component operable to supply voltage to the controller, and wherein the supplying act includes the act of supplying voltage from the power component to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold.

99. The method as set forth in Claim 98 wherein the power component includes a capacitor operable to supply voltage to the controller, and wherein the supplying act includes the act of supplying voltage from the capacitor to the controller such that the voltage supplied to the controller is at least one of equal to and greater than an operating  
5 voltage threshold.

100. The method as set forth in Claim 98 wherein the power component includes a battery cell operable to supply voltage to the controller, and wherein the supplying act includes the act of supplying voltage from the battery cell to the controller such that the  
10 voltage supplied to the controller is at least one of equal to and greater than an operating voltage threshold.

101. The method as set forth in Claim 94 wherein the circuit includes a switch operable to selectively interrupt the transfer of power between the cell and the electrical  
15 device, and wherein the enabling act includes the act of controlling the switch such that the voltage supplied by the cell to the controller is at least one of equal to and greater than an operating voltage threshold.

102. The method as set forth in Claim 101 wherein the switch includes a FET,  
20 and wherein the enabling act includes the act of controlling the FET such that the voltage supplied by the cell to the controller is at least one of equal to and greater than an operating voltage threshold.

103. The method as set forth in Claim 94 and further comprising the act of  
25 supplying power from the cell to the electrical device to operate the electrical device.

104. The method as set forth in Claim 103 wherein said battery pack is a power tool battery pack, wherein the electrical device is a power tool, and wherein the supplying act includes the act of supplying power from the cell to the power tool to operate the  
30 power tool.

105. The method as set forth in Claim 94 and further comprising the act of, with the controller, interrupting the transfer of power between the cell and the electrical device.



106. The method as set forth in Claim 105 wherein the cell is operable to supply power to the electrical device to operate the electrical device, and wherein interrupting act includes the act of interrupting the supply of power from the cell to the electrical device.

- 5           107. The method as set forth in Claim 105 wherein the electrical device is a power tool, and wherein the interrupting act includes the act of interrupting the supply of power from the cell to the power tool.